

AD-A163 087

Human Factors Analysis of the Multiple Launch Rocket System (MLRS) in Operational Test III

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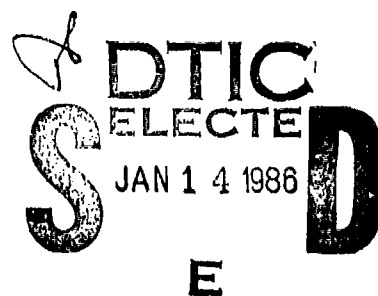


U. S. Army

Research Institute for the Behavioral and Social Sciences

December 1984

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARI Research Report 1387	2. GOVT ACCESSION NO. ADA 163087	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HUMAN FACTORS ANALYSIS OF THE MULTIPLE LAUNCH ROCKET SYSTEM (MLRS) IN OPERATIONAL TEST III		5. TYPE OF REPORT & PERIOD COVERED August 1982 - January 1983
		6. PERFORMING ORG. REPORT NUMBER ---
7. AUTHOR(s) William K. Earl and Lloyd M. Crumley		8. CONTRACT OR GRANT NUMBER(s) ---
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue, Alexandria, VA 22333-5600		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q263739A793
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue, Alexandria, VA 22333-5600		12. REPORT DATE December 1984
		13. NUMBER OF PAGES 28
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) ---		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE ---
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) ---		
18. SUPPLEMENTARY NOTES The appendixes to this report are available through Chief, Army Research Institute Field Unit, PERI-SH, Fort Hood, TX 76544. They con- tain detailed summaries of all data collected and copies of all questionnaires and survey instruments (Classification SECRET).		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Crewstation design Surface to Surface Rocket System Human factors engineering design XM270 Multiple Launch Rocket System Operational test and evaluation		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) An analysis of the human factors design and related considerations of the Multiple Launch Rocket System (MLRS) was conducted in conjunction with the MLRS Operational Test III. Eighty probable or confirmed human factors, train- ing and organizational deficiencies are identified. Twenty-three of these are considered serious enough to result in significant reductions in operational effectiveness if left uncorrected. The methods used to obtain the human fac- tors data are described, and summarized data and analyses are (Continued)		

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1 SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ARI Research Report 1387

20. (Continued)

presented. Results of the evaluation are discussed and their implications are considered. This report provides the Army with data that identify needed design changes in succeeding production models of the MLRS Self Propelled Launcher Loader and Ammunition Resupply Vehicle. The data also provide a basis for the development of design criteria for future similar systems. ↗

Human Factors Analysis of the Multiple Launch Rocket System (MLRS) in Operational Test III

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Office, Deputy Chief of Staff for Personnel
Department of the Army

December 1984

Army Project Number
2Q263739A793

Human Factors in Training &
Operational Effectiveness

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FOREWORD

This report presents the results of research regarding human factors (man/machine interface) and related considerations of the Army's XM270 Armored Vehicle Mounted Rocket Launcher (called the Self Propelled Launcher Loader) and companion Ammunition Resupply Vehicle (called the Heavy Expanded Mobility Tactical Truck) which are the main subsystems of the Multiple Launch Rocket System. The research was conducted in conjunction with the Multiple Launch Rocket System Operational Test III (MLRS OT III). The Army Research Institute's Fort Hood and Fort Sill Field Units performed a joint effort in support of the Operational Test and Evaluation Agency (OTEA), the test agency for MLRS OT III. The test was conducted at Fort Bliss, TX. This analysis is part of an ongoing ARI program of research on human factors and training aspects of Army weapons systems, with emphasis on system development and system evaluation. ARI developed the research design, data collection and analysis plans, and test materials in coordination with OTEA. The report presents the results of interviews, questionnaires and debriefings administered to the test unit personnel in MLRS OT III. The main purpose of the report is to identify problems in the human engineering design of initial production XM270 Rocket Launchers and ammunition resupply vehicles. The findings provide information to correct the problems on future production series vehicles and as input to the design of future vehicles.



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HUMAN FACTORS ANALYSIS OF THE MULTIPLE LAUNCH ROCKET SYSTEM (MLRS) IN OPERATIONAL TEST III (OT III)

EXECUTIVE SUMMARY

Requirement

The human factors and related analyses of the MLRS were conducted in conjunction with the OT III for the MLRS. This OT was designed to provide information on the capabilities of initial production XM270 Armed Vehicle Rocket Launchers and companion Ammunition Resupply Vehicles in an operational environment. The data were needed to aid the decision process of placing the vehicles into full scale production. The ARI Field Units - Fort Hood and Fort Sill cooperated in a joint effort to support the test agency (OTEA) by performing the test functions for human factors, training and related considerations. The scope included addressing 49 specified data requirements distributed over the five test objectives: mission performance; RAM; logistics supportability; training; and organization, doctrine and tactics.

Procedure

An initial training period of MLRS crews was followed by a pilot test. At the conclusion of the pilot test training questionnaires were administered to the MLRS player personnel. This was followed by debriefings discussing training problems identified in the questionnaires. During the primary field test human factors data were collected from players, controllers, and data collectors and by observations of test events, interviews and reports. The data were recorded by human factors analysts and filed in a manually maintained data file. The file was analyzed and problem areas were identified. At the end of OT III, human factors questionnaires were administered. They were followed by debriefings which discussed and analyzed problems identified in the questionnaires and from problem areas identified during testing.

Findings

Results from the data analysis indicated a total of 80 probable or confirmed human factors, training and organizational inadequacies of which 23 were judged to be serious enough to induce significant reductions in operational effectiveness. On both vehicles there were design problems with lighting for control and reloading equipment. On the rocket launcher neither the gunner's fire control panel nor the boom controller are equipped with instrument lights for night operations. On the ammunition resupply vehicle the cargo loading equipment is not furnished with a lighting system for providing illumination for reloading at night. Other significant problems with the rocket launcher are in communications, crew station design, and safety.

The system cannot transmit free text messages and the intercom is obstructed by electronic noise; the seats and workspace in the crewstations are inadequate; the heater exhaust port blows diesel smoke into the cab; and the hold-down latch handles can injure the operators. Other significant problems with the ammunition resupply vehicle are with the outriggers which are very difficult to operate manually and the truck's suspension system which provides an excessively hard ride that punishes both the crew and onboard equipment.

Classified findings have been omitted from this report. This report, with classified findings included, is included in its entirety as Appendix, Human Factors, in OTEA Report FTR-OT-407, Multiple Launch Rocket System Operational Test III, April 1983 (SECRET).

Utilization

This report provides the basis for initiating modifications in training, tactics, operational procedures, and engineering design in order to minimize the degrading efforts of identified MLRS problems. It also provided the basis for the development of a set of design criteria for future similar systems.

The findings presented in the report have been integrated into OTEA Report FTR-OT-403, Multiple Launch Rocket System Operational Test III, April 1983 (SECRET) and OTEA Report IER-OT-403, Independent Evaluation of the M270 Armored Vehicle Rocket Launcher (Multiple Launch Rocket System), November 1983 (SECRET). The report is included as Appendix A to OTEA Report FTR-OT-403 referenced above.

HUMAN FACTORS ANALYSIS OF THE MULTIPLE LAUNCH ROCKET SYSTEM (MLRS) IN OPERATIONAL TEST III

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I. INTRODUCTION

The Multiple Launch Rocket System Operational Test III (MLRS OT III) was conducted at Fort Bliss, Texas from 19 October to 13 December 1982. It was a comprehensive test of the Self Propelled Launcher Loader (SPLL) and Ammunition Resupply Vehicle (RSV) to provide data and associated analysis on the operational effectiveness and suitability of the MLRS to the Army System Acquisition Review Council/Defense Systems Acquisition Review Council (ASARC/DSARC) IIIa. The information will partially serve in assisting the ASARC/DSARC in making a full scale production decision. The Army Research Institute (ARI) supported the test effort and collected data that dealt with human factors, training, safety, mission performance, RAM (Reliability, Availability and Maintainability), logistics supportability, organization, doctrine and tactics.

II. PURPOSE

The primary purpose of the ARI effort was to assist in improving the mission effectiveness of the MLRS during both day and night operations by identifying human factors, safety and training problems that materialize in an operational environment, and by recommending corrective modifications in the following areas: personnel and operator selection procedures, training systems, doctrine or tactics, organization, and/or equipment design. The secondary purpose was to provide a data base that would permit the development of design criteria for future similar systems from analyses of problems in the current system.

III. METHOD

A. Requirements

In a series of conferences with OTEA staff personnel of the MLRS OT III Test Directorate, ARI was tasked to obtain data in each of the five test objective areas for which RDRs were defined. A total of 49 Reduced Data Requirements (RDR's) distributed as follows, were assigned to ARI.

1. Mission Performance	23
2. RAM	8
3. Logistics Supportability	4
4. Training	6
5. Organization, Doctrine and Tactics	8
TOTAL	49

B. General Procedures

A pilot test was conducted immediately following the MLRS training period. The data collection effort began at the end of the pilot test when the training questionnaires were administered to the MLRS player personnel. This was followed by debriefings discussing training problems identified in the questionnaires. During field exercises, human factors data were collected from players, controllers, data collectors, observations of test events, interviews and reports. The data were recorded by the human factors analyst and filed in a manually maintained data file. The file was analyzed and problem areas were identified. At the end of the field exercises the human factors questionnaires were administered and analyzed. This was followed by debriefings discussing identified problems.

C. Questionnaires

A series of questionnaire segments were developed, each dealing with a specific RDR. The type and number of questions per segment varied considerably depending upon the nature of the RDR under consideration. The number of questions per segment ranged from one to over forty. The longer sets of questions dealt with specifics of operator station arrangements and operating tasks where more detail was required.

The complete set of questions were used as the basis for assembling questionnaires for a total of 12 different MLRS job areas specified in the RDRs as the player elements to be surveyed. Thus a complete questionnaire was composed of a set of packets of questionnaires, each packet covering one RDR, specifying one of the 12 job areas as the survey element or respondent. Each complete questionnaire contained the set of packets covering all the RDRs for one MLRS job area or element. Eleven of the questionnaires included items addressing RDRs under both the training and other objectives. Since training data was to be collected before testing and the other data after testing, each of these job area questionnaires was subdivided into two questionnaires: one called the training questionnaire, containing the items related to the training RDRs and the other called the human factors questionnaire, containing the items for the RDRs under the other four objectives. The complete set of 23 questionnaires was then submitted for review and approval to the OTEA MLRS OT III on-site Test Director. The modifications proposed by the on-site Test Director were accepted and included in the final versions.

Table 1 presents the player elements, numbers of players receiving each questionnaire and location in the appendices. In all, a total of 129 players were surveyed.

D. Player, Data Collector and Controller Interviews

Player, data collector and controller interviews were conducted during Phase III testing. One of the purposes of the interviews was to record incidents of human factors problems occurring during OT III which were observed by the players, data collectors and/or controllers. Individuals reporting occurrences of human factors problems were interviewed by the human factors analyst who documented the information. Personal observations of human factors problems by the human factors analyst were also documented. In addition, analysts from the Data Management Section of the OT III Test Directorate submitted written comments from data collectors concerning human factors problems in the area of RAM. These items were also recorded.

TABLE 1

PLAYER ELEMENTS RECEIVING EACH QUESTIONNAIRE, ELEMENT
SAMPLE SIZE AND LOCATION OF EACH QUESTIONNAIRE IN THE
APPENDICES.

PLAYER ELEMENT	TRAINING QUESTIONNAIRES SAMPLE SIZE	APPENDIX	HUMAN FACTORS QUESTIONNAIRES SAMPLE SIZE	APPENDIX
BATTERY HQ	2	A ¹	2	L
BATTERY FDC	6	B	5	M
AMMO PLT HQ	8	C	7	N
FIRING PLT HQ	13	D	13	O
SPLL SECTION CHIEF	8	E	8	P
SPLL GUNNER	10	F	8	Q
SPLL DRIVER	12	G	8	R
SURVEY SECTION	2	H	1	S
RSV DRIVER	31	I	31	T
ORGANIZATIONAL SUPPORT (OS) MAINT SECTION	12	J	5	U
DIRECT SUPPORT (DS) MAINT SECTION	16	K	3	V
BN FIRE DIRECTION CENTER (FDC)	NA ²	-	9	W

¹Appendices A through W are voluminous and are not included in this report. The appendices are on file at the ARI Fort Hood Field Unit and will be provided upon request.

²The BN FDC was a scenario unit and not part of the test unit (MLRS Battery). It did not participate in MLRS unit training.

E. End of Test Debriefings

At the end of the test, the players were administered the human factors questionnaire covering their particular job assignment in MLRS. The RDRs under objectives 1, 2, 3, and 5 were included for evaluation. Upon completion of the questionnaires, players were interviewed concerning problems identified in the questionnaires and problems observed by players, controllers, data collectors and the human factors analyst during testing.

IV. RESULTS

The results are presented by individual RDR in the *appendices to this report and an overview of the results is included below in the body of the report.

A. Description of Individual RDR Entries

The results of the individual RDRs are presented in Appendix I. They are organized into sections according to each RDR. Each section presents a summary of findings derived from analysis of all the data sources related to the RDR. The sections are generally organized into four sub-sections: (1) the RDR number and statement of the data requirement, (2) the MLRS elements responding to the RDR (surveyed elements) and reference information on the location of relevant source data summarized in the questionnaires which are in Appendices A to W, (3) a summary presentation of findings on components given satisfactory ratings and judgements, and (4) a summary presentation of findings on components given unsatisfactory ratings and judgements.

B. Summary of Results by Test Objective

The summary of results are presented according to the five major areas discussed in the methods section, with further subdivision where required.

1. Mission Performance

This area is presented in five subsections.

a. MLRS information processing capabilities. The adequacy of the communication interface between the battery FDC and battalion FDC was rated by most FDC personnel as adequate for controlling and supporting one battery. However, the battalion operations office and an FDO felt that the battalion FDS does not have the capability to effectively control three MLRS batteries during surge operations. The battalion FDC personnel also noted that their FDC had significant maintenance and transmitting problems with their radio equipment. They felt that the transmitting range of their equipment will be inadequate for the dispersion distances expected to be used in actual tactical deployments.

Intervening crests were never a consideration in FDS fire mission analysis due to the flat terrain on which the test was conducted. Thus the effects of the intervening crest variable were not tested in complicating FDC calculations of fire mission solutions.

FDC procedures used for processing single and multiple fire missions were rated as very adequate. FDS display and digital message capabilities used in performing fire mission functions and in controlling firing section deployment were rated as effective. However, FDC personnel reported that some of the Battery Computer Unit (BCU) software program subroutines did not function properly which necessitated the substitution of manual work-around procedures. This caused some reduction in SPLL mission performance resulting in inadequate execution of a few fire missions.

*The appendices to this report are available through Chief, Army Research Institute Field Unit, PERI-SH, Fort Hood, TX 76544. They contain detailed summaries of all data collected and copies of all questionnaires and survey instruments (Classification SECRET).

The Platoon Leaders Digital Message Device (PLDMD) was rated as effective for performing all but one of the communication and data processing tasks it was assigned in the test. Users judged it as unreliable to use for monitoring digital messages sent between the FDC and SPLs. It is incapable of receiving messages which are out of serialization, a condition that occurs frequently. It appears that this limitation disqualifies the PLDMD as the device to use for performing the message relay and backup function, and for providing CONOPS support.

The capabilities of the SPL's on-board fire control system (OBFC) to provide necessary reports and information to the FDC and firing platoon HQ were rated as adequate except for its inability to transmit free text messages. The SPL crewmen thought that it is essential that this capability be added to the OBFC.

b. Related functions. Functions rated and judged to have been performed adequately with no significant problems were MLRS control operations (CONOPS) techniques, survey support capabilities and procedures, coordination of terrain usage, battery/platoon command and control and Readiness Standard Operating Procedures (RSOP) capabilities and procedures, span of control of junior leaders, manual data entering procedures in the SPL, and Stabilization Reference Package/Position Determining System (SRP/PDS) update requirements on SPL responsiveness.

c. Communications.

This paragraph has been omitted from this unclassified document.

It is included in Appendix A, Human Factors to USAOTEA Report FTR-OT-403, Multiple Launch Rocket System Operational Test III, April 1983. (SECRET)

d. SPL capabilities, procedures and human factors. In general, the crewmen rated SPL capabilities and operating procedures as adequate and effective for successfully performing basic mission requirements. They rated the system as adequate for performing the major function, sub-functions and tasks comprising its operational mission. The SPL was rated as having adequate capability for effectively performing such functions as mobile operations under field conditions, performing fire mission procedures, reloading cycles, communications operations, maintenance and sustained operations within the requirements defined by the tactical organization and concept prescribed for its employment.

Although the SPL does not appear to have any fundamental design deficiencies, it does have a considerable number of significant human factors and equipment design problems that reduce its potential effectiveness.

There were a number of man/item components that large proportions of SPL crewmen rated as difficult to operate or inadequate in their performance. Other components were identified in comments or in the debriefings as being deficient and causing problems. The components will be presented and described according to the general functional areas of the vehicle to which they are a part starting with the crewmen's work stations.

(1) Section Chiefs Station.

(a) Section chiefs seat. The seat has a number of deficiencies. It was rated as very uncomfortable. The seat pan and backrest do not provide adequate support for sitting in for the long periods demanded by mission requirements. The chief's roof hatch is located directly above the seat and the fold-down back rest is not designed as a platform for standing on as it should be when using the hatch.

(b) Heater exhaust port. The exhaust port is located close behind the section chief's door. When the heater is operating and the door is open diesel exhaust smoke enters the cab. This occurs whenever the section chief or gunner must enter or leave the cab in the normal performance of their duties. To eliminate all contamination the heater exhaust port must be relocated further away from the section chief's door. This problem appears to have the potential for being a serious safety hazard to the extent of endangering the lives of the crewmen from carbon monoxide poisoning. An incident occurred during the pilot testing in which one crew was incapacitated from the effects of heater exhaust smoke. The incident signals a warning that a hazardous condition exists in the present design and that other crews will eventually suffer carbon monoxide poisoning unless modifications are made.

(c) Workspace. Legroom and bodyspace in the section chief's station was rated as inadequate for working and living in for the long time periods required. The cramped workspace will tend to reduce operator effectiveness and accelerate fatigue and need for additional rest.

(d) Section chief's door. The armored door is difficult to operate partly because the door handles stick in the closed position and are difficult to release.

(e) M-16 rifle rack. The section chiefs were very dissatisfied with the gun rack muzzle clamps. The present arrangement makes it very difficult to remove and replace the rifle in the rack.

(f) Ballistic window. The ballistic window is difficult to open and close and the curtain is difficult to operate.

(g) Section chief's hatch. Several section chiefs indicated that the hatch is very difficult to operate.

(h) Suspension lockout. It is difficult for section chiefs to monitor the mode settings of the suspension lockout system from their workstation.

(2) Gunner station.

(a) Gunners seat. Gunners rate their seat as very uncomfortable and lacking adequate support. The seat pan is hard and causes soreness. The seat back causes pain in the area of the lower back.

(b) Workspace. The majority of gunners rated the headroom, legroom and bodyroom in the gunners station as inadequate for working and living in.

(c) Heating and ventilation. Several gunners rated the quality of heating and ventilation at their workstation as inadequate.

(d) Fire control panel (FCP).

This paragraph has been omitted from this unclassified document.
It is included in Appendix A, Human Factors to USAOTEA Report FTR-OT-403, Multiple Launch Rocket System Operational Test III, April 1983. (SECRET)

A second problem with the FCP is that it is mounted on a rigid base that transfers vibrations from the carrier. This makes it difficult to operate while the SPL is moving. Since mission requirements necessitate FCP interaction at all times during operations the FCP should be equipped with a new mount that dampens out travel induced vibration.

(3) Driver's station.

(a) Driver's seat. The majority of drivers rated their seat as uncomfortable and lacking adequate support for long periods of occupation.

(b) Workspace. The majority of drivers indicated that workspace and bodyroom for working and living for long periods of time is inadequate.

(c) Suspension lockout pump. The pump handle is located in a poor position that makes it difficult for either the driver or gunner to operate.

(d) Instrument panel light settings. Drivers reported having difficulty driving at night with night vision goggles because the illumination from indicator lights on the instrument panel degrades the imagery. All panel lights need to be completely dark when using Night Vision Goggles (NVGs). Some of them cannot be turned off with the present adjustment control and they are the ones that cause the problems.

(e) Driver's window. The top of the driver's window is too low for many drivers who are above average in height. Tall drivers must bend their backs to see out of the window when driving. This unnatural postural position is very discomfoting producing fatigue and physical problems.

(f) Driver's windshield wiper. The windshield wiper is not located in the correct position. It does not cover the right side of the window which is a critical area. The driver does not have an adequate field of view of the right front area when operating in wet weather.

(g) Blackout lights. The drivers feel that the blackout lights do not illuminate the forward field of view adequately for safe driving. Driving is hazardous with the present lights (unless night vision goggles are worn).

(h) Louver adjustment control. The control that opens and closes the driver's louver is unreliable. Sometimes it will fail during travel allowing the louvers to slam shut blocking out the driver's view. This problem is also a serious hazard that must be corrected.

(i) Location of fire extinguisher. The fire extinguisher is located directly under a heater vent which blows directly onto it. To avoid overheating and a possible explosion, the extinguishers are being stowed under the section chief's seat.

(j) Driver's stowage compartment. The compartment is located behind the driver's seat back. It contains bottles of drinking water which are very difficult to remove when they are full. This is because access is restricted mainly by the seat back which is permanently attached and cannot be folded down like the section chief's seat back. The crewmen consider this problem to be a major annoyance because the water bottles are high use items requiring frequent stowing and unstowing.

(k) Air filter panel. The screw down latches on the air filter panel located behind the driver's seat are difficult to fasten and release.

(4) Intercom system.

(a) Digital net noise. Whenever messages are transmitted over the digital secure net the intercom net receives it as digital noise and blasts it into the crewmen's ears. They are unable to communicate over the intercom when digital messages are being received. The problem is extremely annoying and bothersome. The crewmen disconnect their intercoms to avoid the noise and use voice communication and hand signals. This problem obviously reduces communication, teamwork and crew proficiency significantly.

(b) Cab air pressure fan. Noise produced by the operating fan is also picked up by the intercom and blocks communication. The fan must be turned off to use the intercom.

(5) Launcher loader module (LLM).

(a) Umbilical cable connectors. Crewmen indicated that it is very difficult to connect and disconnect the cable connectors. They cite two reasons contributing to the problem. The compartment in which the connectors are housed lacks adequate workspace for the crewmen to insert their hands and manipulate the connector parts. The problem is compounded when crewmen wear gloves as they often do. The connector itself becomes more difficult to connect and disconnect when it gets dirty. It is difficult to keep the connectors clean in the field environment which raises the question of whether the connector is of suitable design for hard field service conditions.

(b) Hold down latch handles. The hold down latch handles were rated by crewmen to be difficult and dangerous to operate because of the great pressure when in the locked position. When unlatching the handle it must be held firmly or it will swing out quickly with great force and cause injury if it strikes the crewmen. One crewman suffered a severe head injury from being struck by a

latch handle he was latching during pilot testing. If the handle must be used under such high pressure, consideration should be given to attaching a safety device to the assembly to prevent a free swinging handle from striking the operator.

(c) Boom controller. The boom controller is not equipped with panel and indicator lights for night operations. Crewmen have to use flashlights for illuminating the control panel. They must hold the flashlight in one hand or under an arm either of which makes the task more difficult, awkward and dangerous. Loading live rocket ammunition with heavy hoisting equipment is an inherently dangerous job to begin with. There is no justifiable reason to make it unnecessarily more dangerous. This problem must be corrected.

(d) Stowage containers. The latches on the stowage containers mounted on the under side of the LLM tend to get damaged and broken from normal service. They need to be replaced with stronger models. The center stowage container is poorly designed. The container door is attached to the bottom of the compartment. Stowed contents fall out of the container whenever the door is jarred open by shocks from rocket firings or travel over rough terrain.

(6) Engine, cab and hull.

(a) Battery box. The latching nuts on the battery hold down brackets require too much time to remove. They should be replaced with wing nuts.

(b) Engine access door. The crewmen complained that the engine access door is in a poor location. To gain access to the access door the crewmen must clear out the work stations and then raise the gunner's seat out of the way.

(c) Engine hour meter. The meter is located down on the engine which makes it difficult to reach. Drivers would prefer that it be mounted on their instrument panel available for reading at all times.

(d) Cab raising mechanism. The crewmen are concerned about the safety of the elevating screw rod that raises and lowers the cab. They feel that when holding the cab in the raised position it might break under the weight, allowing the cab to fall on the crewmen working underneath it.

(e) Hull drain plugs. The hull drain plugs are too small and do not provide rapid drainage of the rear hull area. Furthermore, they are not located at the lowest points of the drainage area where they must be to accomplish complete drainage.

(7) Stowage space. The crewmen held divided opinions on the adequacy of total stowage space in the SPL. Some felt it was barely adequate while others felt it was very adequate. There was greater agreement on their assessment of stowage space inside the cab. The majority of crewmen felt it was very inadequate.

e. Unusual conditions and safety considerations. Performance degradation resulting from Mission Oriented Protection Posture (MOPP) conditions appeared to be a function of the amount of physical labor and effort involved in the job. The performance of SPL crews, who perform most of their tasks sitting at their crew station, was rated as undergoing only a small reduction in proficiency when in MOPP. The drivers of Ammunition Resupply Vehicles (RSVs), who perform strenuous manual labor in

loading and unloading Launch Pod Containers (LPCs), estimated it was very difficult to perform their job when wearing the protective uniform. Also, the organizational and DS mechanics indicated that it was difficult when wearing the protective uniform to carry out the maintenance tasks necessary to keep the SPLLS available.

The SPLL crews felt that the blast effects and toxic fumes produced by the rocket firings did not significantly degrade their performance. The SPLL section chiefs had some reservations about the safety of the hangfire procedures recommended in the operator's manual. They do not like the concept of pointing the LLM over the side of the vehicle while driving away from the launch point. It is a dangerous practice because the SPLL is out of balance and can easily turn over. Moreover, the majority of crewmen feel the recommended procedures are dangerous to perform although none actually performed the hangfire task since the situation did not occur in OT III.

The personnel in the firing platoon and SPLLS rated their equipment and procedures to be safe except for a few items. PSV drivers rated most of the components on their truck to be safe, but there were many items rated as having problems. The LPC hold down latch handles are the only items of operating equipment on the SPLL that the majority of crewmen rate as being hazardous. Maintenance conditions considered to be dangerous are working under the LLM and SPLL cab when they are elevated.

The FDC personnel feel strongly that their facility does not have the capability to operate under warm weather conditions. The FDC is not provided with cooling equipment to control the ambient temperature inside the vehicle which exceeds 100° in hot weather. As a result, the radio equipment overheated and burned out during the initial training conducted in the summer at Fort Sill.

The RSV drivers rated reloading at night as very dangerous because the RSV is not equipped with a lighting system designed for the purpose. This is an obvious design deficiency because the mission requires the RSV to perform reloading operations day and night.

2. RAM.

In general, the MLRS maintenance concept was felt to be basically sound, but it is hampered by several operational and organizational deficiencies that significantly degrade mission performance. The majority of mechanics judged that the MLRS maintenance allocation charts are in error in not assigning many tasks to the SPLL crew that it is capable of performing. This misallocation reduces SPLL availability because the SPLL crew has to wait for maintenance support to arrive to make repairs that they could have done themselves in a shorter time. Many special tools and spare parts that are necessary for making routine repairs on SPLLS and which are needed constantly are not authorized to be maintained in inventory at the battery maintenance section. There are not enough 63T track vehicle mechanics authorized to maintain the 13 track vehicles in the battery. Finally, there are deficiencies in vehicle authorizations that degrade maintenance support. The SPLL and communications mechanics are not authorized their own transportation vehicles and they have no reliable means of transport to the widely dispersed SPLLS. Thus response time to calls for maintenance support is prolonged increasing SPLL nonavailability. The battery is not authorized its own track recovery vehicle and the mechanics feel that it needs one to have adequate capability in this area.

3. Logistics (RSV) supportability

RSV capabilities, procedures and human factors. Overall, the crewmen rated RSV capabilities and operating procedures as adequate for performing basic mission requirements for ammunition resupply support, but with major reservations. The truck was rated as capable of performing the principle functions comprising its mission. It possesses adequate capability for effectively performing such functions as hauling a full load of LPCs on improved roads, unimproved roads and trails during day and night and inclement weather, executing loading and unloading operations, communicating over radio nets, and performing maintenance and sustained operations within the requirements defined by the tactical organization and concept prescribed for its employment. The RSV appears to possess the potential capability required for mission success, but the test has revealed that some of its major subsystems were not designed to meet requirements and must be totally replaced by more effective alternatives. Also, the RSV is troubled with a large number of significant human factors and design problems which seriously degrade its effectiveness. These problems are discussed below.

Two major subsystems failed completely during the test and had to be withdrawn from participation. They were the resupply trailer (RST) and the crane on the RSV. The trailer was incapable of operating on unimproved roads when carrying a load of LPCs, its basic function. The crane was not designed with adequate structural strength or power to handle the weight of an LPC, its basic function. Unofficial reports were circulated that action is being taken to replace these subsystems with different types and models.

There were a number of man/item components that large proportions of RSV crewmen rated or commented upon as difficult to operate or unsatisfactory in performance. The components will be discussed according to the functional areas of the vehicle to which they belong starting with the driver's station.

(a) Driver's crew station

(1) Driver's seat. The seat was rated as unsatisfactory by a large proportion of crewmen. They commented that the problem is exacerbated by the tightly sprung suspension system which produces a hard ride for the crew and vehicle.

(2) Workspace. An unexpected number of crewmen rated workspace in the station as very unsatisfactory, but there were no additional complaints made during the debriefing on this subject.

(3) Cab lighting. Cab lighting was rated as satisfactory but there are three particular items that are seen as problems. One, the dome light is not equipped with a red light or filter for night operations. Two, lighting for map reading is rated as unsatisfactory by many crewmen. Three, the transfer case indicator light on the instrument panel interferes with using the night vision goggles. Apparently there is no control provided to turn it off.

(4) Vision obstructions. A large number of drivers rated their vision of the right side field of view as unsatisfactory. About one half of the drivers indicated that the mirrors were unsatisfactory.

(5) Radio. The transmission range of the VRC-160 radio is deemed to be inadequate for maintaining contact with commanders on resupply runs.

(6) Compass. The drivers expressed a strong need to have a compass mounted inside the cab for use as an aid for map reading and navigation.

(7) Brakes. Many drivers complained that the brakes perform poorly when operating on range roads.

(8) Watertight seals. The seals around the roof hatch and doors leak water during rains discomforting the crewmen. Water collects on the floor and is difficult to remove. The drivers suggest that drains should be installed on both sides of the cab to correct the problem.

(9) Suspension and riding quality. The majority of drivers rated the RSVs suspension system and the riding quality of the vehicle when unloaded and traveling on unimproved roads as unsatisfactory. They feel that the hard ride and constant pounding on the crew and vehicle is a significant problem. It fatigues the crew and damages onboard equipment such as the heater fans. One way to adjust the ride is to change the tire pressure. The crewmen point out that there is no practical way to do this now because it takes too much time to do it manually. They suggest that what is needed is a powered tire pressure adjustment system that will quickly adjust the tires to the optimum pressure for the changing road conditions.

(10) Blackout lights. The blackout lights are rated as very unsatisfactory by the majority of drivers. They do not provide adequate illumination of the road for safe driving.

(11) Trailer lights. The cable connector for the trailer lights is ineffective. It frequently disconnects during travel shutting off the lights. Drivers estimate that they had trailer lights operating only about half the time during testing.

(12) Backup lights. The backup lights on the rear of the RSV are located too close to the trailer hitch. They need to be moved outward. The drivers explained that a large number of backup lights were broken in the test when attempting to hitch the trailer at night. If the RSV hitch is out of line with the trailer hitch, which is frequently the case at night, the RSV backup lights will be smashed into the trailer hitch when the vehicles come together.

(13) M-16 rifle racks. The drivers complained about the difficulty of removing and replacing the M-16 in the rifle clamps installed in the cab.

(14) Cab doors. The doors latches tend to stick shut and are difficult to open.

b. Cargo section.

(1) Outriggers. The task of extending and deploying the outriggers was rated by the overall majority of drivers as difficult or very difficult. There are several problems involved. It is difficult to line up the holes on the boom extensions for inserting the locking pins and then pushing the pins into

the locked position. The unattached base plates sink below the surface on muddy ground and when the equipment gets dirty the drivers say its almost impossible to work with. Many of them feel that a powered system is needed for deploying the outriggers.

(2) Crane remote control box. The remote control box for operating the crane was criticized as performing poorly. Its feedback dynamics are very bad; it overcontrols, undercontrols and has long periods of control lag at times. The drivers suggest that the difficulty may be that the remote controls are electrical and the main controls are hydraulic which cause interface problems.

(3) Crane main controls. The drivers stated they want to have the main controls located at the front end of the truck bed and remove the rear controls altogether. They felt that the best location for overseeing the LPCs during reloading is from the front of the truck bed.

(4) LPC tiedown harness. The original 24-strap harness was considered by the drivers as a poor design that requires too much time to attach and tighten down. The 8-strap design is seen as a marked improvement. However, the straps, themselves, are subject to fraying, ripping and tearing and there was a high rate of wastage during the test. Some drivers suggested that protected sleeves be provided to protect the straps from coming into contact with sharp edges and corners on the LPCs.

(5) Tiedown rings. The tiedown rings on the truck bed are judged as being too small and fragile. They need to be replaced by larger and stronger ones that can accommodate three or more straps and snap-on clips. They need to be the same size as the rings installed on the LPCs.

(6) Side panel pins. The side panel pins are difficult to work with especially in cold weather. They are easily lost and misplaced. The drivers suggest that they should be made longer in length for easier handling and attached to the panels by chains or cables to prevent losing them.

(7) LPC pads. The drivers indicated that the locking pins for the LPC pads suffer a high rate of loss because they are an unattached part. They suggest that permanent, spring loaded locking pins might be built into the pad to eliminate the problem.

(8) Stowage space. All the drivers rated the stowage space on the RSV as unsatisfactory. They feel strongly that they need more space than has been provided to stow all the basis issue and TA-50 equipment they must carry with them.

c. Safety hazards

(1) Illumination. The main safety hazard of the RSV is that it is not equipped with a lighting system for providing illumination necessary for performing reloading operations at night safely and efficiently. Since night operations are a fundamental part of the RSVs mission, the importance of this problem seems to call for an analytical study to find the most appropriate solution. See RDR 1.6 for additional discussion of the problem.

(2) Ammunition resupply procedures. The RSV drivers rated the tasks of loading LPCs onto the RSV/RST at the Ammunition Supply Point (ASP) and offloading the LPCs in the platoon area during the day as easy to perform with no significant safety problems involved. The SPLL crewmen and firing platoon HQ personnel rated the tasks of loading the LPCs off the ground during the day and night as easy and safe. The majority of players from the seven surveyed elements rated the ammunition supply procedure used in OT III as adequate. However, when asked to assess whether their element could support a higher fire rate than the test required with no changes in equipment, personnel, or procedures the consensus was that it could not.

The RSV drivers, ammunition platoon HQ players and battery commander indicated that the tasks of loading the LPCs onto the RSV/RST at the ASP and offloading the LPCs in the platoon area during the night was difficult and hindered by significant safety problems. The main problem is lack of adequate illumination of the work area which makes the tasks very dangerous to perform.

(3) Equipment problems in the ammunition platoon. When asked to judge if the ammunition supply function was hindered by equipment problems the battery commander, ammunition platoon HQ, and firing platoon HQ personnel identified several items. Prominent among them were judgements that the RST and RSV crane were incapable of performing their functions.

(4) Personnel problems in the ammunition platoon. The battery commander, ammunition platoon HQ and firing platoon HQ personnel indicated that there are not enough RSV drivers authorized for the battery to handle the workload. The problem disrupts the normal management and control of the platoon, reduces the performance proficiency of the RSV drivers, and causes an increase in accidents and damage to equipment. To compensate for the need for additional drivers the platoon HQ has reassigned section chiefs to RSV crews to fill in for missing crewmen. The result is that they are not available to perform their supervisory functions and the quality of management and control of platoon operations is degraded. The ammunition platoon HQ personnel suggest that two additional drivers should be assigned to each section chief to free him to perform his supervisory duties.

d. POL, mess, and supply. The overall majority of respondents from the three elements agreed that Petroleum, Oils and Lubricants (POL) support was for the most part adequate. Nevertheless, inadequate POL support was judged to have occurred occasionally causing a reduction in mission effectiveness. Reasons given for inadequate support were that the POL truck was not equipped with a radio which it needs for adequate command and control. It is authorized a one-man crew whereas the extensive workload requires a two-man crew for effective performance. The long distance between displaced elements is a major factor causing delays in timely arrival of POL support.

Mess support was rated as good by battery HQ, but as poor by the players from firing platoon HQ and the SPLL chiefs. The battery commander felt that the contributing factors are not enough support equipment and the long distances that must be traveled to reach all the displaced elements.

The battery commander and first sergeant indicated that there were no other items of supply besides POL and mess that became problems due to an inability to furnish them. They expressed confidence that the supply system can meet the battery's needs for other types of items under real combat conditions.

4. Training.

All MLRS elements except the DS Maintenance Contact Team indicated they were prepared to perform their primary position after completing both the Fort Sill MLRS School and the collective training. Both SPLL Section Chiefs and Gunners rated the overall training program satisfactory in terms of quality. However, many gunners and drivers rated the overall amount of training as insufficient. DS Maintenance personnel reported that they did not receive any school training on MLRS and rated their level of preparation as borderline. In rating the Fort Sill MLRS School on the amount of training time devoted to training primary and secondary position duties, the following elements felt that the amount of time devoted to each was just about right: SPLL Section Chief, SPLL Gunner, SPLL Driver, Survey Section and RSV Driver. Elements feeling that more time should be devoted to training on their primary position were: FDC, Ammo Plt HQ, Organizational Maintenance and DS Maintenance. The majority of SPLL crewmen indicated that section chiefs and gunners should be cross trained to the level of being well qualified to perform both jobs and drivers should be cross trained to be well qualified to perform the gunner's job.

Areas of training which need to be improved to produce a higher standard of proficiency in MLRS personnel are communications operations and night operations. The maintenance training both organizational and DS mechanics was hastily organized, incomplete and poorly administered. A new program needs to be established in this area. The operator and maintenance manuals for the main systems in the MLRS were rated as generally adequate although many of them contain errors, organization problems, omissions, and unclear instructions. The biggest deficiency was no operator's manual issued to the RSV driver. They had to rely on a brief instruction pamphlet produced by the battery motor section. The fire control panel training device and the LPC trainer were rated as very adequate whereas the mass simulator was rated as very inadequate.

5. Organization, doctrine and tactics.

This area is presented in three subsections.

a. Mission performance. Equipment and personnel deficiencies which degraded mission performance are identified below.

(1) Track vehicle section. The battery commander, firing platoon HQ personnel and organizational mechanics felt that SPLL maintenance support was degraded because the track vehicle section does not have its own transportation. Thus the 63T mechanics do not have the capability to travel to widely dispersed SPLLs quickly and make repairs. This inadequacy decreases SPLL availability greatly and degrades mission performance. The track vehicle section needs to be authorized at least one jeep to correct the problem.

(2) Tools and parts. The battery commander, firing platoon HQ personnel and mechanics indicated that the mechanics need to be issued additional special tools, equipment and repair parts to have the means necessary to make repairs on the SPLLs in the field.

(3) Personnel. The battery commander feels that the 31V personnel do not have the ability to maintain the radio equipment in the battery. Authorization should be made for a radio repairman qualified to repair the 12 series radios. The ammunition platoon HQ feels they have too few RSV drivers. They estimate they need several more to act as backups for drivers not present for duty. The firing platoon HQ personnel feel they are undermanned and need additional authorizations to perform their mission effectively. Specifically, they request one additional 15J NCO supervisor to operate the PLDMD, one 15 E-3 operator, and one or two 13M drivers.

b. Command and control. The following equipment and personnel deficiencies degraded command and control.

(1) Battery HQ. The battery commander and first sergeant feel they do not have adequate radio equipment for their needs. The commander needs two-way voice communication on the battery and battalion CF nets. They would like to have the battery commander's jeep equipped with two AN/VRC-46 radio sets and the first sergeant's jeep equipped with one AN/VRC-46. They agree that the FDC is undermanned and cannot perform its function adequately due to personnel deficiencies.

(2) Ammunition platoon. The GRC-64 radios issued in the platoon and on the RSVs do not have adequate transmission range which causes Command, Control and Communications (C³) problems within the platoon. They should be replaced with AN/VRC-46 radios. To free section chiefs from having to act as assistant drivers, more RSV drivers should be authorized for the platoon.

(3) Firing platoon. The battery commander and firing platoon HQ personnel indicate that the SPLs suffer command and control problems because they do not have two-way voice capability. They recommend that the SPL should be equipped with one more AN/VRC-46 to provide the capability. The players feel that the PLDMD is not an effective device for monitoring messages between the FDC and SPL. It is suggested that a AN/VRC-46 should be authorized to each platoon HQ to use for monitoring. The battery commander and platoon leaders feel that the platoon HQ are undermanned. There is a definite need for another qualified NCO supervisor to help provide 24 hour management of the SPLs.

c. Maintenance. The following equipment and personnel deficiencies degraded maintenance support.

Tools and equipment. The battery commander and the maintenance mechanics recognize that the mechanics need to be authorized an additional set of special tools before they can effectively repair SPLs in the field. The firing platoon HQ is unable to adequately maintain the equipment in its M577 because it lacks the necessary tools. Tool kits for the PLDMD are needed along with equipment to maintain storage batteries. The battery commander, firing platoon personnel and the mechanics, themselves, all agree that there are not enough 63T mechanics assigned to adequately handle the workload of supporting nine SPLs and four M577s. The battery commander recommends that the authorization for 63T mechanics be increased to 6 per battery with the section commanded by an E-6, 63T. Likewise, the wrecker truck has a heavy workload and it should be authorized a two-man crew.

V SUMMARY OF RESULTS

The most significant results are summarized below:

A. SPLL

1. The gunner's Fire Control Panel is not equipped with panel and instrument lights for night operation. The gunners reported that the labels, numbers, and scales on the keys, knobs, and switches cannot be seen when operating the FCP at night.

2. The heater exhaust port is located closely behind the section chief's door and blows diesel exhaust smoke into the cab when the door is open exposing the crew to carbon monoxide poisoning and resulting in illness.

3. The seats and workspace in the crew stations are inadequate for use for the long time periods demanded by mission requirements. The top of the driver's window is too low for taller drivers to see out of; it adds to the discomfort and contributes to fatigue and physical problems.

4. The incapacity of the On Board Fire Control System to transmit free text messages is a major deficiency.

5. The intercom system is not properly shielded. It receives noise and interference from digital transmissions and electric motors forcing the crew to communicate by unaided voice and gesture much of the time.

6. Drivers had difficulty driving at night with night vision goggles because the indicator lights on the instrument panel wash out the enhanced imagery.

7. The blackout lights are hazardous to drive with because they do not illuminate the road adequately.

8. The Umbilical Cable Connectors are too difficult to connect and disconnect.

9. The Boom Controller is not equipped with panel light for night operations. Crewmen must use flashlights to illuminate its control buttons and labels when operating it.

10. The Hold Down Latch Handles are a safety hazard.

B. RESUPPLY VEHICLE (RSV)

1. The RSV is not equipped with a lighting system for night illumination of the working area used for reloading operations. On the questionnaires RSV drivers rated reloading at night as hazardous because of poor visibility conditions.

2. The Outriggers are difficult to deploy and stow.

3. The Suspension System provides an excessively hard ride which causes constant pounding and vibration stress on the crew and on-board equipment.

4. The control and feedback dynamics of the Remote Control Box for the crane were rated as very poor.

C. FIRE DIRECTION CENTER.

1. FDC personnel reported that the FDC equipment cannot operate under summer heat conditions where temperatures inside the M577 regularly reach 100°F or higher. The vehicle is not equipped with a cooling system to keep the BCU and commo equipment from overheating and burning out.

2. The FDC is currently undermanned for performing its MLRS functions effectively.

D. COMMUNICATIONS.

1.

Omitted from this unclassified document. This paragraph is included in Appendix A, Human Factors to USAOTEA Report FTR-OT-403, Multiple Launch Rocket System Test III, April 1983. (SECRET)

2. The radio equipment installed in the jeeps of the battery commander and first sergeant is inadequate to exercise effective command control.

3. The SPLs provide inadequate command control capability for FDC, firing platoon personnel and SPL chiefs because the SPL is not equipped with a radio dedicated to the battery voice net.

4. The GRC-64 radios installed in the RSVs and ammunition platoon are inadequate for use by ammunition platoon personnel and RSV drivers due to a limited transmitting range.

5. The POL and vehicle recovery trucks should be equipped with radios to provide adequate command control of these assets.

E. TRANSPORTATION ASSETS

Maintenance support was significantly degraded because the SPL mechanics and commo repairman are not authorized vehicles for transporting them to the widely dispersed SPLs.

F. PERSONNEL AUTHORIZATIONS

The following battery elements are under strength in personnel authorizations which significantly degrades mission performance: FDC, firing platoon HQ, RSV drivers, 63T track mechanics, and POL truck drivers.

G. TRAINING

The training program for the organizational and DS mechanics was developed hastily and administered poorly. The mechanics were not adequately trained for participation in the test.

VI MAJOR CONCLUSIONS

1. The operational design of the SPLL and RSV appear to be adequate only in their basic characteristics. The potential mission effectiveness of the MLRS battery is seriously limited by human factors related system design deficiencies in the SPLL, RSV and FDC. Both the SPLL and the RSV have major deficiencies in equipment lighting that degrade night operations. The FDC, which is a makeshift expedient, cannot function effectively in summer temperatures.
2. The fire control panel and boom controller in the SPLL are not equipped with panel lighting for night operations. The workspace, seats, intercom system, and window in the operators stations are all marginal or inadequate and limit crew performance. The heater exhaust port pollutes the crew's air supply with diesel smoke. The RSV was not designed with a lighting system to provide illumination necessary to perform reloading operations at night. It is equipped with a suspension system that transmits excessive vibration forces to the drivers and on-board equipment.
3. The mission effectiveness of the MLRS battery has been compromised by these and other man-machine, equipment design and organizational deficiencies noted in the report. A proper human factors and systems analysis with corrective action should be required on the SPLL and RSV prior to full scale production. The FDC needs to be replaced by a new system designed to perform the MLRS mission.